Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	
Spectrum Horizons	ET Docket No. 18-21
James Edwin Whedbee Petition for Rulemaking to Allow Unlicensed Operation in the 95-1,000 GHz Band	RM-11795

COMMENTS OF QUALCOMM INCORPORATED

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CONTENTS

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Qualcomm supports the FCC's Spectrum Horizons *Notice of Proposed Rulemaking* seeking to authorize commercial wireless operations in the bands above 95 GHz.[1] Given that these ultra-high frequency bands represent largely uncharted territory today in comparison to the heavily used sub-6 GHz bands for mobile broadband and the new sub-6 GHz and millimeter wave bands the Commission already has allocated and are soon to be put in use for 5G services, now is the perfect time to explore opportunities in the above 95 GHz bands. Qualcomm therefore applauds the FCC's foresight to probe these spectrum horizons and propose rules to support research, development, and initial deployments in these new millimeter wave bands.

The pressure on existing licensed mobile and unlicensed spectrum bands will continue to grow, and the bands identified in this docket can play an important role augmenting the spectrum used to support America's wireless connectivity needs over the long term. Accordingly,

[1] *See* Spectrum Horizons, *Notice of Proposed Rulemaking*, FCC 18-17, ET Docket No. 18-21 (Feb. 28, 2018) ("*NPRM*").

Qualcomm respectfully requests that the FCC authorize both fixed and mobile operations in these bands using both licensed and unlicensed regulatory paradigms, as explained herein.

INTRODUCTION & SUMMARY

Qualcomm supports the FCC's proposals in the *NPRM* that recognize the explosive growth in wireless communications services and the concomitant need to explore all opportunities to making available additional wireless spectrum, including the spectrum horizons' bands above 95 GHz.[2] Qualcomm requests that the FCC adopt flexible use rules so that both fixed and mobile deployments will be allowed in the spectrum horizons' bands below 160 GHz. As the Commission rightly recognizes, opening these bands for commercial services can "lead to new and novel communications opportunities in an uncrowded frequency range, [and] pay dividends by reducing pressures in lower parts of the spectrum."[3]

Indeed, given "all the potential services and devices that might be developed in this spectrum are not yet known," now is the right time to move forward and encourage exploration and experimentation in the bands above 95 GHz. In fact, these spectrum bands are under study in Europe for commercial deployments.[4] Thus, it is critically important for the U.S. government to look to these bands to keep a steady stream of spectrum flowing for commercial uses to maintain American leadership in 5G and future wireless service generations by delivering ultra-high speed mobile broadband connectivity, ultra-low latency and ultra-high reliable applications and services. These spectrum horizons' bands may also be well suited for wireless Personal Area

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2 *See, e.g., NPRM* at ¶¶ 2, 20.

3 *See id.* at ¶ 2.

4 *See* European Conference of Postal and Telecommunications Administrations European Communications Office (CEPT/ECC) Work Programs Database, Reference SE19_37, SE 19_38, http://eccwp.cept.org/; http://eccwp.cept.org/WI_Detail.aspx?wiid=534 ; http://eccwp.cept.org/WI_Detail.aspx?wiid=535 .

Networks ("PANs") and radar applications. Commission support for all of these uses, as well as uses we cannot necessarily envision today, will help to propel American technological leadership well into the 21st century.

The FCC has done outstanding work thus far to open additional spectrum in the bands below 95 GHz for 5G services, and with this *NPRM* offers to open sizable swaths of spectrum to maintain American wireless technology leadership. As the leading 5G wireless technology developer, Qualcomm encourages the FCC to move forward in this proceeding along the lines proposed below.

DISCUSSION

I. Qualcomm Is The Industry Leader In Developing Millimeter Wave Technology For 5G

As the wireless industry leader in developing RF modems for wireless devices in general and for 5G millimeter wave devices in particular, Qualcomm is excited by the possibilities of enabling operations in the spectrum horizons' bands above 95 GHz. When compared to the bands below 95 GHz, the spectrum horizons' bands can offer greatly improved spectrum utilization and sharing using the revolutionary technologies and deployment models discussed below.

A. Qualcomm Chipsets Are Powering 5G Deployments Around The Globe

Qualcomm continues to be a mobile industry leader with its 5G New Radio (5G NR") mobile chipsets that operate in the millimeter wave bands, and our company is well positioned to develop RF capabilities for these new spectrum horizons' bands.[5] Our 5G chipsets use licensed,

[5] *See* Qualcomm Press Release, "Global OEMs Select Qualcomm Snapdragon X50 5G NR Modem Family for Mobile Device Launches in 2019— Qualcomm and Mobile Device OEMs Focus on Delivering Next-Generation 5G Mobile Experiences with Low Latency, Extreme Capacity and Fiber-Like Connectivity to the Cloud," (Feb. 8, 2018) *available at*

unlicensed, and shared spectrum to deliver improved mobile broadband connectivity with fiber-like speeds.

We expect that RF operations in the bands above 95 GHz will build upon the technologies Qualcomm has developed to support millimeter wave operations in the bands already allocated by the FCC. Broadly speaking, the small wavelengths at these millimeter wave frequencies allow for miniaturized antennas, a large number of which can be packed into a very small area and be intelligently controlled. These antennas use adaptive beamforming to dynamically find the most efficient signal path direction, which includes non-line-of-sight paths that travel around corners and down corridors and alleys, reflecting off walls and buildings. And, where a particular millimeter wave connection cannot be maintained, the RF modem can automatically switch to a different millimeter wave band or a lower frequency band to maintain connectivity.[6]

Years ago, Qualcomm pioneered the development of 802.11ad technology for use in the 60 GHz unlicensed band.[7] 802.11ad technology offers five times greater throughput than 802.11ac technology that operates in the 5 GHz unlicensed band while operating with similar power consumption. 802.11ad uses a radio module containing dozens of antennas that dynamically establish very narrow beams focused towards particular users. This beamforming technology operates in channels up to 2 GHz wide to provide multi-gigabit user speeds.

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https://www.qualcomm.com/news/releases/2018/02/08/global-oems-select-qualcomm-snapdragon-x50-5g-nr-modem-family-mobile-device.

[6] *See* Qualcomm Snapdragon X50 5G Modem Infographic," *available at* https://www.qualcomm.com/products/snapdragon/modems/5g/x50, *last accessed* May 2, 2018.

[7] *See, e.g.*, Qualcomm 802.11ad website, "Pushing the limits of high-speed Wi-Fi," *available at* https://www.qualcomm.com/solutions/networking/features/80211ad, *last accessed* May 2, 2018.

B. Increased Densification Using Small Cells That Support The 28 and 39 GHz Millimeter Wave Bands Can Also Incorporate The Bands Above 95 GHz

The deployment of 5G NR technology is shifting the cellular network infrastructure paradigm to densified networks of small cells that provide highly-reliable, ultra-high-speed, multi-band operations. This shift towards increased network densification is necessary to support increasing demands for ultra-high speed and ultra-reliable mobile broadband connectivity and the technical realities of 5G millimeter wave technology that operates with shorter signal paths.

Facilitating small cell deployments will enable broadband delivery using millimeter wave spectrum bands along with lower bands and increased access to both unlicensed and other shared spectrum bands.[8] The millimeter wave bands — including the spectrum horizons' bands above 95 GHz — are well-suited to small cells, as they can be placed strategically, in very close proximity to where additional coverage/performance is needed.[9] With light technical regulations, such as those proposed in the *NPRM,* the spectrum horizons' bands can be put to use in small cells in a timely manner.

C. The Spectrum Horizons' Bands Can Support Revolutionary Sharing Techniques That Provide Even Greater Spectral Efficiency For Multiple Users Operating On The Same Spectrum In The Same Location

Qualcomm is actively developing novel techniques to provide even greater spectrum utilization among multiple users in the same geographic area and on the same piece of spectrum. Our wireless technology research teams have shown how combining spatial sharing with

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8 *See* Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment, *Second Report and Order*, WT Docket No. 17-79, FCC 18-30 (Mar. 30, 2018).

9 *See* Dean Brenner, Qualcomm OnQ Blog, "FCC acts to accelerate small cell deployments & 5G readiness," (Apr. 12, 2018) *available at* https://www.qualcomm.com/news/onq/2018/04/12/fcc-takes-action-accelerate-small-cell-deployments-and-strengthen-5g-readiness, *last accessed* May 2, 2018.

network synchronization provides much improved overall network performance.[10] These tools can support a sustained Quality of Service ("QoS") even during extremely high loading conditions.

As noted in Section I.A above, the use of multiple antennas is becoming increasingly common in wireless systems that operate in the higher frequency bands. These multi-antenna systems — the physical size of which is substantially smaller for the bands above 95 GHz when compared to the already small size of the antenna systems that support 28 and 39 GHz — allow the transmission links to become highly directional, and this directionality can be exploited to significantly improve spectrum reuse and greatly increase overall system capacity. For instance, spatial division multiplexing ("SDM") and coordinated multipoint sharing ("CoMP") techniques allow for the creation of highly focused beams to specified directions along with beam steering. These techniques enable multiple radio links to simultaneously communicate on the same channel and in the same geographical area, not only for the radio nodes of a single operator but also for the nodes of multiple operators. Advanced sharing techniques such as time-division multiplexing also enable guaranteed spectrum access for services that require a given QoS, which vastly increases spectrum efficiency and value.

Qualcomm is working closely with many other wireless industry stakeholders to standardize these techniques for operation in shared spectrum bands and in unlicensed spectrum bands.[11] The work to standardize these 5G New Radio for Unlicensed and Shared Spectrum (NR-U/SS) tools in 3GPP began last fall at an industry-wide workshop that Qualcomm hosted in

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[10] *See* Yongbin Wei, Qualcomm OnQ Blog, "What can we do with 5G NR Spectrum Sharing that isn't possible today?" (Jan. 3, 2018) *available at* https://www.qualcomm.com/news/onq/2018/01/03/what-can-we-do-5g-nr-spectrum-sharing-isnt-possible-today, *last accessed* May 2, 2018.

[11] *See id.*

San Diego. The ongoing 3GPP study is enabling the development of new sharing paradigms, targeting greenfield shared and unlicensed spectrum to deliver significant benefits in terms of increased spectral efficiency, improved throughput, and a guaranteed QoS.

5G NR-U/SS holds the promise of enabling wireless system operators, including those with very limited or no licensed spectrum, to offer fiber-like 5G experiences within new shared or unlicensed bands. Qualcomm is making great progress in this area.[12] At Mobile World Congress 2018, we showcased a live demonstration of the benefits of NR-SS showing two operators each providing more than 1 Gbps connectivity in the same geographic area over the same 100 MHz swath of spectrum.[13]

II. Qualcomm Supports FCC Action To Open Flexible Use Bands Above 95 GHz

A. The Commission Should Allow Both Licensed Mobile And Fixed Operations

Qualcomm agrees with the Commission that mobile access and point-to-point links can be deployed above 95 GHz with a limited reduction in the maximum path length of the links caused by increased atmospheric loss.[14] The FCC should thus authorize flexible use licenses to deploy mobile and fixed services in these seven bands just above 95 GHz in the same manner it has done for the millimeter wave bands: 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, and 151.5-158.5 GHz bands. Qualcomm

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12 *See* Dean Brenner, Qualcomm OnQ Blog, "Wireless innovation — From LTE-U/LAA to 5G spectrum sharing," (Mar. 29, 2018) *available at* https://www.qualcomm.com/news/onq/2018/03/29/lte-u-5g-spectrum-sharing *last accessed* May 2, 2018.

13 A video of the "5G NR Spectrum Sharing (March 1, 2018)" demonstration is accessible on Qualcomm's 5G Spectrum Sharing website *available at* https://www.qualcomm.com/invention/technologies/5g-nr/spectrum-sharing *last accessed* May 2, 2018.

14 *See NPRM* at ¶ 23.

encourages the FCC to permit point-to-point operations, with link lengths of several hundred meters or less, and mobile use cases.

Qualcomm has successfully developed 5G NR technology for fixed and for mobile use cases in the 28 GHz, 39 GHz and other millimeter wave bands as described above, and 5G integrated access and backhaul solutions are being developed by 3GPP as part of Release 16. Considering the 5G network topologies that support integrated mobile access and backhaul in the same swath of spectrum, we believe that providing the same level of flexibility for operations above 95 GHz can provide intensive and spectrally efficient use of these spectrum horizons' bands. FCC implementation of limited technical rules to govern operations in the spectrum horizons' bands "will encourage greater use of these bands because equipment will likely be less expensive and licensees will have more flexibility in the uses they can make of this spectrum."[15] Such an approach would allow the "lower" spectrum horizons' bands (*i.e.*, below 160 GHz) to successfully support both mobile and fixed operations.

B. Technical Realities Of Above 95 GHz Operations Enable High Spectral Reuse

Given the very focused "pencil beam" style of both transmitters and receivers in the bands above 95 GHz, Qualcomm has observed through its development and testing of millimeter wave 5G NR-U/SS technology operating at 28 GHz, for example, that spectrum sharing among multiple users operating in the same swath of spectrum (*i.e.*, on the same "channel") in the same geographic area can be achieved via spatial separation of beams. We expect this technical reality to be even more pronounced in the spectrum horizons' bands.

For instance, because the incremental impact on a first system due to the introduction of a second system (or even a third system) in the same area and on the same spectrum can be

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15 *NPRM* at ¶ 33.

minimal, deployment planning can be greatly simplified and technology proliferation made easier. Consequently, the need for complex rules to govern spectrum sharing is reduced.

Given these technical realities, the FCC should allow point-to-point, point-to-multipoint, and mobile operations in the "lower" spectrum horizons' bands identified above, *i.e.*, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, and 151.5-158.5 GHz, as 5G NR-U/SS technologies are being developed for many different use cases that operate with highly beamformed transmissions and can support multi-user MIMO configurations.[16]

Qualcomm is currently studying the appropriate maximum transmit power levels for point-to-point, point-to-multipoint, and mobile operations to enable spectrally-efficient integrated systems in the spectrum horizons' bands. The maximum EIRP for point-to-point operations proposed in the *NPRM* is 75 dBm/100 MHz, which is equivalent to the maximum transmit power allowed in 28 and 39 GHz. Qualcomm believes that this level is an appropriate starting point for experimentation and R&D, and we will keep the Commission apprised of our ongoing technical work as we may propose different maximum power levels as our development work and 3GPP's standardization efforts in this area progresses. The end goal of the 5G NR-U/SS techniques described above and being standardized in 3GPP is to support ultra-reliable, low latency, high-speed broadband communications.

The Commission should similarly authorize point-to-point operations in the spectrum horizons' bands with an FSS or MSS allocation by applying the 70/80/90 GHz framework set out in paragraph 32 of the *NPRM*. The fact that sharing between point-to-point operations and satellite operations has worked in bands below 95 GHz is proof positive that it can work above

16 *See NPRM* at ¶ 38.

95 GHz where the point-to-point beams are even more tightly focused and less likely to cause interference to satellite operations.[17]

In addition, Qualcomm supports the FCC's proposal to codify that first-in-time use of a spectrum horizons' band does not necessarily mean priority relative to current or future licensed or unlicensed users in a given band above 95 GHz.[18] This approach makes good sense because it is not wise to prevent a new innovative spectrum use in this greenfield spectrum because of an early deployment where it can be replaced with a more efficient system and also given that 5G NR-U/SS technologies can support multiple uncoordinated operators in the same area without causing interference.

III. Qualcomm Supports Opening Additional Unlicensed Spectrum Above 95 GHz

Qualcomm supports the FCC authorizing 15.2 GHz for unlicensed use within the four bands proposed in the *NPRM*: 122-123 GHz, 174.8-182 GHz, 185-190 GHz and 244-246 GHz.[19] At this early stage of deployments in the spectrum horizons' bands, Qualcomm recommends that the Commission apply the rules in Section 15.255 governing unlicensed operations in the 57-71 GHz band; however, the agency should remain open to modifying the Section 15.255 rules for some or all of the spectrum horizons' bands if certain rule changes can improve spectral efficiency and service to end users.

A natural consequence of operating in these ultra-high frequency bands with very narrow beams and limited propagation range allows for spectrum sharing among multiple users within the same general area without causing harmful interference to one another. Such technical

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17 *See NPRM* at ¶ 39.

18 *See id.* at ¶ 42.

19 *See id.* at ¶¶ 53-56.

realities can reasonably lead the FCC to consider opening additional spectrum bands above 95 GHz to unlicensed use.

IV. The Proposed Modifications Of The Experimental Licensing Rules Will Help Spur The Development Of Innovative Wireless Services Using the Bands Above 95 GHz

Qualcomm supports the creation of a new subpart of the FCC's Part 5 Experimental Radio Service rules to encourage intensive research, development, testing, and deployment of services and applications in the spectrum horizons' bands.[20] Providing experimental licensees a longer experimental license term of up to ten years with the ability to market equipment for use over a broad geographic area will spur greater experimentation and R&D and thus more rapid innovation in these bands.[21] We believe this new approach can lead to wireless technology breakthroughs.

V. FCC Equipment Authorization Rules Should Be Extended Above 100 GHz So Equipment That Operates In The Spectrum Horizon Bands Can Be Approved

When the FCC authorizes fixed and mobile licensed and unlicensed use of the bands above 95 GHz, it should extend the RF exposure rules up to 300 GHz, which is the upper range of the IEEE RF exposure standard on which current FCC limits are based.[22] This will allow technology developers to begin assessing the capabilities of deploying equipment and services in these spectrum horizons' bands.

Should the FCC subsequently decide to relax its RF exposure rules in the context of the broader RF exposure proceeding, it can provide relief for the bands at issue in this proceeding at that point to the extent the broader proceeding requires additional time. Having in place rules that

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20 *See NPRM* at ¶ 63.

21 *See id*. at ¶ 79.

22 *See id.* at ¶ 82.

apply above 95 GHz will allow technology developers to begin work in the spectrum horizons' bands as soon as possible, and their efforts can possibly inform the broader RF exposure proceeding. This approach will ensure that there are "appropriate authorization mechanisms in place so that when new devices that use these frequencies become available, users will be able to begin operations without delay."[23]

Qualcomm also supports the FCC's proposed approach for authorizing equipment that operates in the bands above 95 GHz to use the procedures that apply to the 70/80/90 GHz bands for fixed service equipment, which uses self-certification, and to adapt its UMFUS rules for the bands proposed for mobile devices, which use certification.[24]

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23 *NPRM* at ¶ 19.

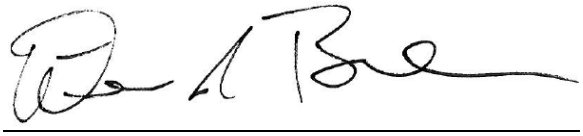
24 *See id.* at ¶86.

CONCLUSION

Qualcomm encourages the FCC to open the spectrum horizons' bands for mobile and fixed services along the lines described above. 5G networks will require additional licensed, unlicensed, and shared spectrum to support the growing demands for enhanced mobile broadband, massive IoT, and mission critical services, and the bands identified in the *NPRM* can support these needs. Qualcomm is very excited by the possibilities of using the bands above 95 GHz because we believe they can serve a critical role in providing ultra-reliable, ultra-low-latency, multi-gigabit per second applications and services to American consumers and businesses.

Respectfully submitted,

QUALCOMM INCORPORATED

By: 

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